REMARKS

Claims 1-14 were objected to on the basis that "the motion data" in Claims 1 and 6 lacks antecedent basis. It was suggested by the examiner that the claims require a positive recitation of obtaining motion data. This has been done. Claim 1 has been amended to recite "acquiring a plurality of ultrasound images comprising motion data where motion is present in the imaged region." Claim 6 has been amended to recite " acquiring a sequence of spatially dimensioned ultrasound images in which a motion characteristic is displayed by motion data." Since these claims have been amended to positively recite obtaining the motion data discussed later in the claims, it is respectfully submitted that Claims 1-14 are now in proper form.

Claims 1-14 were rejected under 35 U.S.C. §102(b) as being anticipated by US Pat. 5,941,826 (Goujon). Amended Claim 1 describes a method for producing a spectrogram from a plurality of two or three dimensional ultrasound images depicting motion comprising acquiring a plurality of ultrasound images comprising motion data where motion is present in the imaged region; delineating a region of interest (ROI) in one of the images, the ROI comprising a plurality of spatially discrete pixels of motion data; forming histograms of the motion data of the spatially discrete pixels of the ROI in a plurality of images containing the pixel information over a plurality of defined temporal intervals; mapping the histograms to temporally discrete display elements; and displaying the display elements as a spectrogram for the ROI. As is well known and described on page 1 of the present specification, there are two ways to display ultrasonic Doppler information. One is a two or three dimensional anatomical image in which flow velocity is measured by Doppler processing at points over most or all of the image, then used to color the anatomical image with colors corresponding to the measured velocities at each point. By viewing colorflow sequences in real time, the clinician can see the flow of blood and changes in velocity by the changing colors in

blood vessels and perfused tissue throughout the heart cycle. The other way to display Doppler information is in a spectral Doppler display. In spectral Doppler, an ultrasound beam is repeatedly transmitted to the same point in the body, a sample volume, which is marked on an image with a sample volume cursor as discussed on page 2 of the present specification. Echoes returning from the sample volume are Doppler processed to determine the instantaneous distribution of flow velocities at the sample volume at successive points in time. Each distribution of velocities at each point in time is displayed as a spectral line in a scrolling spectral Doppler display. The spectral Doppler display gives the clinician specific, detailed information of the flow characteristics at one point in the body, whereas the colorflow image gives a subjective sense of flow dynamics over a large region of the body. Generally, a clinician will acquire a colorflow image and, if an abnormal flow condition appears to be present at a particular location in the image, the clinician will then examine that location in detail with spectral Doppler.

But a particular patient may have been examined by acquiring only colorflow sequences without spectral Doppler information, or the spectral Doppler acquisition done at a different point in the body than one which is identified in later review of the colorflow sequences. But the data for the point in the body where spectral Doppler information is subsequently desired is absent. The only alternative is to reschedule the patient for another exam. However the present invention enables an approximate spectral Doppler display to be formed with colorflow data. This is done by indicating a region of interest (ROI) in a colorflow image where the spectral Doppler information is desired. A small circle or box can be placed over a blood vessel in the image, for instance. The motion data from the pixels in the area inside the circle or box is then used to form a histogram of the motion data. Histograms formed in this manner from successive images are then used to form the spectral lines of a Doppler spectrogram display. Unlike the

spectral lines of a normal spectral display, the histogram data comes from spatially different points in the delineated ROI, not from the single point of a sample volume. Also, since a new spectral line can only be formed when there is a new image, the data rate is far less than that of a conventional spectral Doppler display, and hence the time resolution is less. But the spectral Doppler display synthesized from the spatially discrete colorflow motion data can be sufficient for the clinician to decide whether or not to recall the patient for a second exam.

Goujon does not do this, or anything similar to it. What Goujon is doing is automatically computing the angle correction for Doppler measurements. As is well known, Doppler measurements of flow velocity are precisely correct when the direction of flow is in the direction of the transmitted ultrasound beam, that is, the direction is toward or away from the transducer and the Doppler angle is zero. As the direction of flow varies from this ideal, an error is introduced into the Doppler shift estimate. This is because the Doppler equation contains a cosine term of the angle between the beam direction and the flow direction. Goujon states the Doppler equation at col. 5, line 46 which is:

v=c dt/(2T cos(DA)

where DA is the Doppler angle. When the direction of flow is perpendicular to (across) the beam direction, the Doppler angle is 90°, the Doppler response drops to zero and motion cannot be detected. This problem is compounded by the fact that many blood vessels of interest are generally parallel to the skin surface and therefore generally orthogonal to the transmitted ultrasound beams. For this reason, as Goujon states, ultrasound systems try to consistently measure flow at a Doppler angle of 60° and then correct for this angle. As seen in col. 3, lines 41-51 of Goujon, what Goujon is doing is measuring the Doppler angle for a beam direction and blood flow direction, comparing the measured Doppler angle with an optimum value like 60°, then changing the beam steering to be at or close to an angle of 60°. The Doppler equation would then use a

fixed angle correction for a 60° Doppler angle.

Goujon also describes the basics of ultrasound Doppler usage described above. Goujon refers to colorflow images in col. 5, lines 56-57, where he calls them "color speed maps." He also describes spectral Doppler imaging by its displayed Doppler spectrum in col. 5, lines 58-68. Goujon also explains that spectral Doppler is done at a particular point in the body when he describes aiming the Doppler beam ("line RF") at a point in a blood vessel where spectral Doppler analysis is to be done. Goujon refers to his sample volume as a "resolution cell." See col. 5, lines 11-16 of Goujon. For a visual explanation of how spectral Doppler data acquisition is done in practice, see Fig. 1 and its explanatory text in US Pat. 6,464,637 (Criton et al.)

But Goujon does none of the delineating, forming, mapping, or displaying steps of Claim 1. This is because Goujon does not use motion values from spatially discrete pixels. He has no need to when doing his Doppler angle correction technique. The Examiner tries to find the delineating step at col. 7, lines 30-40 of Goujon. But this is the first step in Goujon's angle correction, which is indicating a vessel of interest with a computer mouse. He does this on a grayscale image, which has no motion information, referring to "echographic image" and "grey level" in the image, which is intensity data, not motion data. His processor then draws radial ray lines intersecting at the point indicated with the mouse as shown in Fig. 3, and Goujon forms a histogram of the grey level values along each ray line and examines the values to find the intersection of the ray line with the blood vessel wall. To see another description of how such a histogram is used to find a vessel wall, see Figs. 7a-7c of US Pat. 6,491,636 (Chenal et al.) and their textual description. Consequently Goujon neither delineates a ROI, nor a region where motion data may be found. It follows that Goujon also cannot form histograms of motion data of spatially discrete pixels, the forming step of Claim 1.

The Examiner then skips back to col. 6, lines 10-60 of Goujon

to find the processing of motion data from image points of a delineated ROI, the mapping of histograms of spatially discrete motion data to display elements which are displayed in a spectrogram, the last two steps of Claim 1. But this passage is seen to be a general description of standard colorflow imaging (color speed mapping) in col. 6, lines 10-30, followed by a description of standard spectral Doppler imaging in lines 31-60. Goujon refers to the spectral lines of a spectral Doppler display as histograms, which is a common description. These histograms are the values of frequency bins produced by a standard Doppler processor as described in col. 1 of the Mo et al. reference. The histogram is the sequence of frequencies corresponding to the distribution of flow velocities produced by the Doppler processor from the sample volume at any given point in time. For a visual description of the values of the histogram, see the points on the graph of Fig. 1 of US Pat. 5,634,465 (Schmiesing et al.) This histogram of values is displayed as one spectral line on a spectral Doppler display such as that shown in Fig. 5 of Schmiesing et al. Spectral line 30, for instance, has a range of flow velocities from zero cm/sec to twenty cm/sec, for instance. This data is from a single sample volume, or "resolution cell" as Goujon calls it. Accordingly the last two steps of Claim 1 cannot be found in Goujon either. For these reasons it is respectfully submitted that Goujon cannot anticipate Claim 1 and its dependent Claims 2-5.

Amended Claim 6 describes a method for displaying the distribution of a motion characteristic occurring at a region of interest in a two or three dimensional ultrasound image of the body comprising acquiring a sequence of spatially dimensioned ultrasound images in which a motion characteristic is displayed by motion data; delineating a region of interest (ROI) in one of the images where motion data is present in a plurality of spatially different points in the image; processing the motion data from the image points of the delineated ROI to determine the distribution of a motion characteristic as a function of time; and displaying the

distribution of the motion characteristic as a columnar display element in a spectral display as a function of time. As described above, Goujon does not delineate a region of interest in an image where motion data is present in a plurality of spatially different points in the image, nor does Goujon process such motion data from the image points of the delineated ROI to determine the distribution of a motion characteristic as a function of time, nor does Goujon display the distribution of the motion characteristic as a columnar display element in a spectral display. Accordingly it is respectfully submitted that Goujon cannot anticipate Claim 6 and its dependent Claims 7-14.

The Examiner also relies on the discussion in col. 3, line 63, to col. 4, line 12 of Goujon to support the anticipation rejection. This passage is seen to have nothing to do with the present invention. In this passage Goujon is claiming that his angle correction can be applied to a variety of known Doppler techniques. In col. 3, line 63 to col. 4, line 5, Goujon says his angle correction can be applied to spectral Doppler data. In col. 4, lines 6-9 he says his angle correction can be applied to all of the velocity values along a Doppler line (instantaneous speed profile), which is a line in an image along which velocity estimates are made. See Fig. 4 of US Pat. 5,471,990 (Thirsk) for an example of a Doppler profile line for power Doppler. In col. 4, lines 10-12, he says his angle correction can be applied to an instantaneous blood flow measurement over a section of a blood vessel. See Fig. 5 of Thirsk for an example of how a power Doppler index is computed for a section of a blood vessel. Blood flow rate (also referred to as volume flow) is commonly computed by taking a Doppler cross-section of a blood vessel and computing the average Doppler velocity of all the points in the cross-section of the blood flow in cm/sec, measuring the area of the blood vessel in cm^2, then using the two values to compute a flow rate through the vessel in cc's of blood per second. However, this has nothing to do with forming a spectral Doppler display from spatially discrete motion data values

of a sequence of ultrasound images as is done in an implementation of the present invention.

Claims 1-14 were rejected under 35 U.S.C. §103(a) as being unpatentable over Goujon in view of US Pat. 6,464,640 (Guracar et al.) As shown above, Goujon does not show or suggest any of the steps of Claim 1 or 6 except for the acquiring step. Guracar et al. does one other step, which is to form a histogram of velocity data from different locations in an image. This is described in the passage in col. 3, lines 15-25 referred to by the Examiner, where Guracar et al. use the histogram to derive a quantity. In cols. 13-15 they describe what these quantities are and what they are used for. In cols. 13-15 such a histogram is used to produce a conversion factor quantity used to convert log-compressed ultrasound data values to linear data values. This is useful because some quantification measurements must be done with linear values and not the typical log-compressed values used for imaging. The other use of a histogram in col. 15 is for baseline shift of Doppler velocity bin values which are erroneous because they exceed the Nyquist velocity. The baseline shift is from negative values to positive values to resolve the aliasing problem. Neither is seen to relate to using spatially discrete motion values to produce the columnar display elements of a spectral display. Accordingly it is respectfully submitted that the combination of Goujon and Guracar et al. cannot render Claims 1-14 unpatentable.

Claims 15-17 and 19-21 were rejected under 35 U.S.C. §103(a) as being unpatentable over Goujon in combination with Guracar et al. and US Pat. 6,142,943 (Mo et al.) Claim 15 describes an ultrasonic diagnostic imaging system which provides motion information concerning a location in the body comprising an ultrasound probe which transmits ultrasonic energy and receives ultrasonic echo signals in response; a beamformer coupled to the probe which forms coherent echo signals from spatial locations in the body; a motion processor responsive to the spatial echo signals which produces image data depicting motion; a display responsive to

the image data which produces two or three dimensional images depicting motion on a spatial basis; a user control by which a user can delineate a region of interest in a two or three dimensional image comprising spatially discrete image points depicting motion; a motion characteristic processor, responsive to motion information of the image points depicting motion of the region of interest, and configured to process motion data from a plurality of spatially different pixels in an image to produce a temporally discrete histogram of velocity values, wherein the display displays the distribution of a motion characteristic of the histogram in a spectral display as a function of time for a delineated region of interest. None of these three references have a user control for delineating an ROI of spatially discrete points depicting motion, or using such data in the form of temporally discrete histograms of velocity values as spectral lines of a spectral Doppler display. Guracar et al. use histograms of image data to convert log-compressed data to linear data and to compute a baseline shift correction. Mo et al. are processing Doppler data to adjust the data compression curve and video gray mapping of Doppler data in consideration of the noise level present to enhance the appearance of a spectral display. This has nothing to do with the creation of a spectral Doppler display from the spatially discrete motion data of a colorflow display. Mo et al was cited for its teaching of a beamformer. Accordingly it is respectfully submitted that Claim 15 and its dependent Claims 16-17 and 19-21 are patentable over Goujon and Guracar et al., with or without the addition of Mo et al.

In view of the foregoing amendments and remarks, it is respectfully submitted that the informalities have been removed from Claims 1-14, that Claims 1-14 are not anticipated by Goujon, and that Claims 1-17 and 19-21 are patentable over any combination of Goujon, Guracar et al., and Mo et al. Accordingly it is respectfully requested that the rejection of Claims 1-14 under 35 U.S.C. §102(b) and of Claims 1-17 and 19-21 under 35 U.S.C. §103(a) be withdrawn.

In light of the foregoing amendment and remarks, it is respectfully submitted that this application is now in condition for allowance. Favorable reconsideration is respectfully requested.

Respectfully submitted,

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November 24, 2009